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Indian Standard

GUIDE FOR TREATMENT AND DISPOSAL OF EFFLUENTS OF DAIRY INDUSTRY

(Third Reprint AUGUST 1998)

UDC 628·543 (026) : 637 1/ 3

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr5

April 1978

Indian Standard

GUIDE FOR TREATMENT AND DISPOSAL OF EFFLUENTS OF DAIRY INDUSTRY

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Indian Standard

GUIDE FOR TREATMENT AND DISPOSAL OF EFFLUENTS OF DAIRY INDUSTRY

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 8 November 1977, after the draft finalized by the Water Sectional Committee had been approved by the Chemical Division Council.

0.2 With rapid industrialization taking place all over the country, the number of dairies and allied industries is sharply rising. The industry uses large quantities of water and with corresponding discharge of effluents.

0.3 The object of this guide is to compile information on methods of treatment and disposal of dairy industry effluents. The methods have been selected keeping in view the practicability of their adoption in India. The available literature on the subject has been carefully reviewed for recommending the treatment and disposal methods. A list of relevant references is given in Appendix A. As better and more economic methods of treatment are worked out in future, revision of this guide will be taken up. It is hoped that the dairy and allied industries, public health authorities and other related agencies will find this guide useful.

0.4 The permissible limits of pollution of inland surface waters and marine coastal areas by discharge of effluents is laid down in IS : 2296-1974* and IS : 7967-1976†.

The following Indian Standards lay down tolerance limits for industrial effluents:

IS : 2490 (Part I)-1974 Tolerance limits for industrial effluents discharged into inland surface waters : Part I General limits (*first revision*).

IS : 3306-1974 Tolerance limits for industrial effluents discharged into public sewers (*first revision*).

IS : 3307-1977 Tolerance limits for industrial effluents discharged on land for irrigation purposes (*first revision*).

IS : 7968-1976 Tolerance limits for industrial effluents discharged into marine coastal areas.

0.5 Methods of sampling and test for industrial effluents are covered in various parts of IS : 2488‡.

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*Tolerance limits for inland surface waters subject to pollution (*first revision*).

†Criteria for controlling pollution of marine coastal areas.

‡Methods of sampling and test for industrial effluents (Parts I to V).

1. SCOPE

1.1 This standard covers methods of treatment and disposal of effluents from dairy and allied industries. It is a compilation of available data and information on sources, nature, volumes and pollutional effects of the effluents, ways of waste prevention and methods of their treatment and disposal.

2. PRODUCTS AND PROCESSES INVOLVED IN DAIRIES

2.1 Products

2.1.1 The number of products that are made in each dairy depends upon the demand and supply of milk in the region. Many dairies in India restrict themselves to bottling pasteurized and homogenised milk and making *ghee* from soured milk. A few dairies, where supply is larger than local demand, produce milk products such as butter, condensed milk, powdered milk, baby food, ice-cream, cheese and *CHHANA*. A few dairies are also preparing casein.

2.1.2 The preparation of skimmed and toned milk (especially in the lean season) and cheese making are on the increase in India.

2.2 Processes

2.2.1 *Milk Receiving Section* — The milk cans are unloaded at the receiving station and emptied into a receiving tank after testing for fitness and freshness. Cans which are turned sour are segregated. The milk from each lot of cans is weighed and conveyed to the pasteurization and other units.

2.2.2 *Pasteurization* — Pasteurization is accomplished by heating either to 62°C for 30 minutes or at 71°C for 15 seconds followed by chilling to 4°C. The milk is then bottled for distribution.

2.2.3 *Cheese Making* — Cheese is made from milk in which fat to protein ratio has been suitably adjusted. For this milk is run into large cheese vats and the temperature is adjusted. A culture of bacteria, called the 'starter' is added to induce the formation of lactic acid. Rennet is then added to induce coagulation of curd which causes its separation from the whey. When the proper degree of setting of the curd has been reached, it is cut into pieces and, after further adjustment of temperature, is allowed to settle; whey is then run off. The curd is then subjected to various processes depending on the type of cheese to be made.

2.2.4 *Butter, Butter Milk and Skim Milk* — Milk is first passed through centrifugal machines to separate cream and skim milk. Cream is then churned either as such or after ripening with or without culture until butter separates from the liquid and butter milk is left over.

2.2.5 *Ghee Making* — *GHEE* is a very commonly used dairy product in India and is made from cream/butter obtained from fresh or sour milk.

2.2.6 *Casein Making* — The casein content of whole milk is 2·5 to 3·0 percent. When milk becomes sour during hot weather it is used for the preparation of casein. The sour milk is separated to remove fat and the skim milk thus obtained is fed into large vats and treated with acid to precipitate casein which is washed and dehydrated.

2.2.7 *Baby Foods* — The baby food is prepared either by spray drying or roller drying of the milk of cow or buffalo or a mixture thereof.

2.2.8 *Powdered Milk* — Milk is dried in spray drier or roller drier to manufacture powdered milk.

2.2.9 *Other Products* — In recent years an increasing range of products have been made from milk. These products include lactic acid, calcium lactate, albumin, milk sugar and proprietory mixed foods for human consumption or for farm animals.

3. SOURCES, QUANTITY AND CHARACTERISTICS OF EFFLUENTS

3.1 Sources — Effluents arising out of dairy plants include wash water from milk cans, equipment, bottles and floors. They also include portions of spilled milk, spoiled or sour milk, skimmed milk, whey and butter milk. These effluents arise out of (a) rinsing and washing of cans and bottles, tanks or drums, equipment, pipe line and floors, (b) overflows, spillage and leakages from pumps and other equipment, and (c) entrainment during evaporation. Sources of waste waters are given process-wise in the following clauses.

3.1.1 *Effluents from Milk Receiving Section* — The empty cans are drained so as to allow residual milk in the cans to drip into a receptacle and the cans are washed mechanically in an automatic milk can washer. The wash water consists of milk drippings, rinses and washings.

3.1.2 *Effluents from Pasteurization Plant* — Effluents from this section consist of washings of equipment containing acids, alkalies and detergents and floor washings, spills and leaks. It is an accepted practice to wash the entire unit after each shift or batch.

3.1.3 *Effluents from Manufacture of Butter and GHEE* — Butter-milk, washing of churns and small quantity of butter are the main wastes from this process. Sometimes washings of churns, separators and other equipment contain small portions of whole milk, skim milk or cream.

3.1.4 *Effluents from Manufacture of Cheese* — Effluents from cheese manufacture mainly comprise whey, washings from vats, drains, floor, presses and other equipment. The main bulk of the effluent from this unit consists of a mixture of discarded whey and wash water used for cleaning and rinsing the vats.

3.1.5 *Effluents from Casein Plant* — Effluents from this plant primarily contain whey of milk, mineral acids when used for precipitation, and washings. This unit generally functions on a batch basis and hence discharge of effluent is intermittent.

3.1.6 *Effluents from Bottle-Washing Plant* — Bottles and crates are thoroughly washed in this plant using detergents and/or caustic or washing soda in solution. The process is a batch one and effluents are discharged intermittently (generally twice a day). The effluents are generally alkaline due to the use of caustic or washing soda.

3.1.7 *Effluents from Water-Softening Plant and Boiler-House* — Effluents from water softening plants and boiler blow-down are usually small in volume. The boiler blow-down contains suspended solids of mineral origin. Effluents from softening or demineralization plant depend upon the process used. It could be mildly acidic if both cation and anion exchange resins are used or highly acidic or saline if only cation exchange is used.

3.1.8 *Uncontaminated Cooling Water* — Cooling water is utilized in the pasteurization of milk. The spent water, though hot, when it leaves the plant, is not usually contaminated and can be reused after cooling. Some cooling water has to be bled off to prevent build up of inorganics and consequent scaling effects.

3.2 Quantity — The volume of effluents from different dairies seems to vary from 6 to 10 litres per litre of milk processed depending upon the processes used, products made, care taken in the use of water and the quantity of water available. Within a particular dairy, the rate of discharge of the effluent varies considerably from hour to hour. The flow variation over 24 hours at a large product-oriented dairy is shown in Fig. 1. Maximum flow of 5 times the average occurred in the afternoon (1400 to 1600 h) and a minor peak of about twice the average occurred in the early morning hours (0300 to 0500 h).

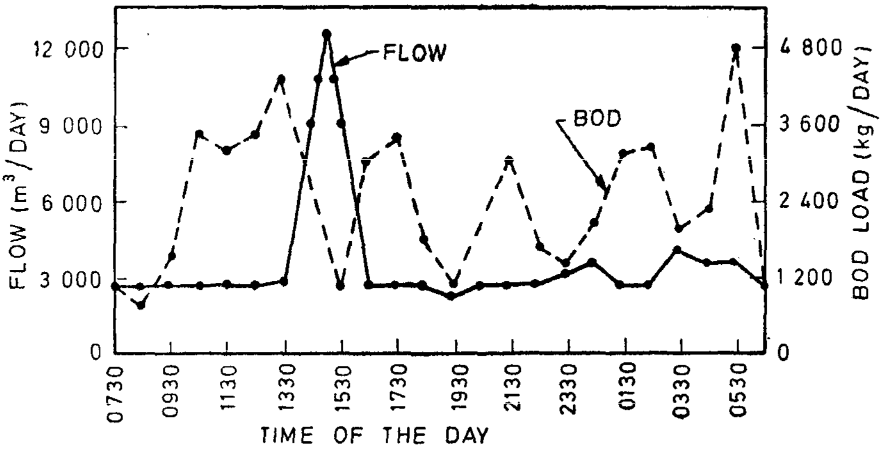

Fig. 1 Variation of Flow and BOD Loads During the Day

3.3 Characteristics

3.3.1 *Individual Effluents* — The nature and composition of effluents from a dairy depend upon the quantity of milk processed and the type of products made.

3.3.1.1 The characteristics of individual effluents from a medium sized dairy processing 60 000 litres of milk per day (mostly bottling, preparation of butter and casein) are given in Table 1.

TABLE 1 CHARACTERISTICS OF INDIVIDUAL EFFLUENTS FROM A MEDIUM SIZED DAIRY

SL No.	CHARACTERISTIC	BUTTER WASHINGS	REJECTED MILK	MILK BOTTLING EFFLUENT
(1)	(2)	(3)	(4)	(5)
i)	*p*H value	4·7	6·6	7·8
ii)	Alkalinity (as $CaCO_3$) (to *p*H 4·5), mg/l	100	10 350	256
iii)	Total solids, mg/l	13 820	85 920	2 560
iv)	Suspended solids, mg/l	5 112	34 904	1 380
v)	Biochemical oxygen demand (5 days at 20°C), mg/l	10 000	62 000	620
vi)	Chemical oxygen demand, mg/l	16 000	88 000	1 000

3.3.1.2 Characteristics of individual effluents from a large dairy processing 360 000 litres of milk per day and producing 30 tonnes of spray dried milk, 10 tonnes of drum-dried milk (baby food), 16·5 tonnes of butter and *GHEE*, 1·5 tonnes of cheese and 3 tonnes of casein per day are given in Table 2.

TABLE 2 CHARACTERISTICS OF INDIVIDUAL EFFLUENTS FROM A LARGE DAIRY

SL No.	CHARACTERISTIC	RECEIVING AND PASTEURISATION UNITS	CHEESE PLANT	BUTTER AND *GHEE* UNIT	CASEIN PLANT
(1)	(2)	(3)	(4)	(5)	(6)
i)	*p*H value	8·2	6·7	7·1	7·7
ii)	Alkalinity (as $CaCO_3$), mg/l	500	490	450	490
iii)	Total solids, mg/l	3 640	2 300	3 400	680
iv)	Suspended solids, mg/l	1 320	600	2 240	160
v)	Biochemical oxygen demand (5 days at 20°C), mg/l	1 820	2 150	1 377	200
vi)	Chemical oxygen demand, mg/l	2 657	3 188	3 218	372
vii)	Oil and grease, mg/l	690	520	1 320	Nil

NOTE 1 — Flow was 6 to 8 litres of effluents per litre of milk processed.

NOTE 2 — Temperature ranged between 29·5 and 35·5°C, the average temperature being 32·8°C.

3.3.2 *Composition of Milk and Byproducts* — It is well known that milk contains carbohydrates such as lactose, protein such as casein, and fats such as butter fat, in addition to minor organic and inorganic materials. There is no set of figures that can be used as average composition of milk under Indian conditions. To incorporate various degrees of variations in percentage figures reported for protein, fat, lactose, etc, would be impracticable. An approximate average composition of milk and its byproducts is shown in Table 3.

TABLE 3 APPROXIMATE AVERAGE COMPOSITION OF MILK AND BYPRODUCTS

SL No.	CHARACTERISTIC	PROTEIN*	FAT	LACTOSE	TOTAL SOLIDS	ORGANIC SOLIDS	BOD	BOD
		kg per 100 kg of the milk						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		percent	percent	percent	percent	percent	percent	mg/l
i)	Whole milk†	3·2	3·9	4·7	12·6	11·8	7·9	80 500
ii)	Skim milk†	3·4	0·1	4·9	9·2	8·4	7·2	70 000
iii)	Butter milk†	3·4	0·5	4·3	9·5	8·8	5·1	51 000
iv)	Whey†	0·9	0·3	4·9	6·9	6·3	4·1	41 500
v)	Whole milk (buffalo)	3·8	7·4	4·9	16·8	16·1	14·7	163 500

*Casein about 80 percent and rest albumin.

†Cow milk.

3.3.3 *Combined Dairy Effluent* — The composition of the combined effluent from a dairy depends upon the quantity of milk processed and the types of products made. The characteristics of effluents from three different dairies are shown in Table 4.

TABLE 4 CHARACTERISTICS OF COMPOSITE EFFLUENTS FROM THREE DAIRIES

SL No.	CHARACTERISTIC	DAIRIES		
		No. 1	No. 2	No. 3
i)	Milk processed, litres/day	12 000	60 000	360 000
ii)	*p*H value	8·1	10·1	8·0
iii)	Alkalinity (as $CaCO_3$), mg/l	50	340	590
iv)	Total solids, mg/l	2 730	790	1 690
v)	Suspended solids, mg/l	1 810	470	690
vi)	Biochemical oxygen demand (5 days at 20°C), mg/l	3 070	950	816
vii)	Chemical oxygen demand, mg/l	4 510	—	1 340
viii)	Oil and grease, mg/l	1 390	—	290

3.3.4 The biochemical oxygen demand in the pasteurization and bottling plants is primarily due to loss of milk into the waste streams. A BOD value of 1 000 mg/l can be considered as a usual average under Indian conditions. Suspended solids form a good portion of the total solids in the combined effluent; oil and grease are relatively high. Volatile solids constitute about 70 to 90 percent of the total solids. The COD to BOD ratio of dairy effluents is in the range of 1·4 to 1·6 indicating their easy biodegradability. The BOD load is 2 to 8 kg per cubic metre of milk processed.

4. POLLUTIONAL EFFECTS

4.1 Discharge into Inland Surface Waters

4.1.1 *Depletion of Dissolved Oxygen* — The most important problem of water pollution associated with dairy effluents is the depletion of dissolved oxygen. As dairy effluents contain all the nutrients essential for bacterial life and, as the water temperatures encountered in most parts of India are ideal for bacterial growth, the rate of decomposition is high resulting in anaerobic conditions followed by bad odours, conditions suitable for fly and mosquito breeding. When discharged into open *NALLAH* and ponds the following adverse conditions are likely to arise:

a) Putrefaction due to rapid degradation of lactose and production of lactic acid and butyric acid leading to foul odours,

b) Fly breeding on the sludge rafts floated by anaerobic decomposition, and

c) Grease floating on the top and adhering to aquatic weeds leading to ugly sight.

4.1.2 *Effect on Fish* — It has been reported that at a dilution of 1 : 15, dairy effluent (excluding whey) had distressing effects on fish. At a dilution of 1 : 35, whey had been found to be toxic to fish in a few hours. Lactic acid can be toxic to fish at a concentration of 654 mg/l of hard water or even less in soft waters and when the dissolved oxygen content is low. Dairy effluents are reported to contain soaps that are toxic to fish at concentrations of 600 mg/l. Butyric acid, a product of anaerobic metabolism, has a very unpleasant rancid odour. Beyond 100 mg/l concentration, it is known to adversely affect and above 400 mg/l to kill trout fish. It is also known to affect *Daphnia* (a crustacean) and *Scenedesmus* (an algae).

4.1.3 *Pathogens* — Dairy effluents can occasionally carry pathogenic bacteria.

4.1.4 *Radioactivity* — Milk as well as its effluents can concentrate strontium 90, a beta-emitting radio-isotope that seeks the bone. This property is of extreme significance when pasture land is contaminated with this isotope due to radioactive spills or fallout of fission products.

4.2 Discharge on Land — While disposal of dairy effluents on land is a common method, not all soils are suitable for this purpose. Heavy soils like clay can lead to ponding, anaerobic conditions and foul odours if the irrigation system is not properly designed.

4.3 Discharge into Public Sewers — As dairy effluents are known to be readily biodegradable, it is often presumed that there is no problem in treating them along with sewage. As they contain significant amount of carbohydrate and the temperature of discharge is ideal, the possibility of sewage water waste mixture becoming septic in the sewer itself is very great and this may need additional pre-aeration in the sewage treatment plant.

5. WASTE REDUCTION AND BYPRODUCT RECOVERY IN DAIRIES

5.1 Waste Reduction — Waste reduction from dairies can be achieved by adopting the following steps:

a) Providing more time for draining the cans either manually or mechanically;

b) Using a small quantity of water in a fine spray after draining the cans and providing further time for draining;

c) Preventing overflowing of milk or other dairy products from vats, tanks and coolers;

d) Preventing boil over in vacuum pans;

e) Checking joints, packing glands and seals daily to prevent leakage;

f) Prevention of foaming in the pipelines by avoiding air leaks in suction lines and splashing in tanks;

g) Prevention of entrainment of milk solids in condenser water in vacuum pans as entrainment can cause losses as high as 1 percent of the total milk processed; and

h) Reduction of the waste volume by segregation of all the clean water streams like condensates and cooling water, from the strong waste.

5.2 Reclamation of Waste Products — The waste waters from dairy industry have been used abroad for the following purposes:

a) Milk drippings and primary rinsing for feeding animals,

b) Combined effluents for breeding carps,

c) Whey after concentration and evaporation as animal feed, and

d) Yeasts produced on whey to be used as animal feed.

5.3 Byproduct Recovery — The recovery processes for usable byproducts are outlined below.

5.3.1 *Butter Milk* — Butter milk resulting from butter manufacture has a higher total proportion of total solids than whey and these can be recovered by roller drying of butter milk after preliminary condensation. The dried powder can be sold as such or incorporated as a source of protein.

5.3.2 *Whey* — A considerable amount of whey results from the manufacture of cheese and because of its high dissolved organic content, it could be economically recovered as a dry powder by pre-condensing in single or two-stage evaporators and spray drying. Spray dried whey can also be used as a source of protein in animal feeds.

5.3.3 *Lactose* — Whey and milk are the main sources of lactose. Recovery of lactose from milk as such may be uneconomical, but lactose present in the effluent, especially whey, can be utilized for culturing of yeast which may be harvested and used as animal feed.

5.3.4 *Casein* — Casein can be obtained from sour milk by treating with acid, which can be washed and dehydrated. In terms of the total milk handled, daily spoilage of milk in India varies from 5·0 to 7·5 percent and this can be used for recovery of casein which is used in the manufacture of resins, plastics, paints and varnishes.

5.3.5 *Butter* — Butter that has turned very sour or rancid or cream which has deteriorated in quality may find use as raw materials in vegetable oil factories.

6. METHODS OF TREATMENT AND DISPOSAL

6.1 Agricultural Utilization System — Land disposal of dairy effluents is one of the most commonly practised methods in India. It can give good results provided the irrigation system is designed properly and the effluent is diluted sufficiently to bring BOD below 500 mg/l. Different irrigation systems tried include (a) ridge and furrow, (b) flood irrigation with under-drains, and (c) spray irrigation.

6.1.1 *Ridge and Furrow System* — In this system effluents are disposed of into furrowed plots of land through a main header ditch into the furrows which are nearly at level and at a slightly higher elevation than the receiving channel. The furrows are 1·0 to 5 m apart, 0·3 to 1·0 m deep and 0·3 to 1·0 m wide. The effluents are allowed to build up only to a depth of 15 cm from the top of the ridges and the flow is regulated by means of a gate. They are usually absorbed in less than 24 hours in the soil. The effluent volume and not the BOD is the usual controlling factor. The advantages of this system over others include (a) longer life, (b) less maintenance, (c) less area requirement, and (d) high BOD reduction. Disadvantages of the system are (i) the system is restricted to open structure, and (ii) it is not possible to graze cattle and to sow cover crops.

6.1.2 *Flood Irrigation* — This system is the simplest and is useful where light soils are prevalent. Where soils are dense (heavy clays), the percolation rates are likely to be quite low. Under the circumstances, the land requirement for irrigation system will be enormous. Under-draining of such lands and by providing unjointed and unburnt clay pipes at a depth of 2 m below the surface would be very useful. The irrigation water should be applied to a height not more than 15 to 30 cm above the surface and should preferably percolate within 24 hours. Land once irrigated should be allowed to remain idle for at least one week to facilitate drying and reaeration. The water drained out through the under-drain system is generally clear and low in BOD. Flood irrigation system especially in dense soils involves capital expenditure in levelling the land, providing under-drainage and trenches for carrying the filtrate.

6.1.3 *Spray Irrigation* — In the spray irrigation system, the waste water is discharged into small sump from where it is pumped to the irrigation site. Waste water is usually applied through sprinklers of 20 mm diameter with nozzle orifice of 4 mm. It is necessary to subject waste water to preliminary treatment, such as fine-screening or settling to remove floating scum and settleable solids prior to entry into the sump. Some of the factors which influence spray irrigation system are: (i) dosing rate, (ii) type of soil, (iii) slope, and (iv) type of cover crop. The factors to be considered in this method of disposal are:

a) land selected should have proper combination of soil characteristics;
b) land available should be adequate to permit easy distribution of solids concentration in the effluents;
c) proximity of the dairy premises to the disposal site;
d) it should ensure protection of underground waters from pollution;
e) it should be located along the direction of wind; and
f) cheap power and suitable anticorrosive equipment should be available.

6.2 Primary Treatment

6.2.1 *Screening* — Screens remove large particles, such as milk bottle caps, and prevent much of the trouble with clogging of pumps and other equipment.

6.2.2 *Grease Traps* — Grease traps are useful in removing oil and grease from the effluents. This step would be essential as a preliminary treatment for biological treatment and agricultural utilization.

6.2.3 *Simple Settling* — Since these effluents contain very little suspended matter, preliminary settling for solids removal does not result in an appreciable reduction of the BOD.

6.2.4 *Chemical Coagulation* — Even though chemical coagulation can remove BOD to a certain extent, the process needs sludge disposal and is expensive. The treatment is not complete. Biological methods would be cheaper for reducing BOD.

6.2.5 *Equalization and Pre-aeration* — The operations of a dairy are not uniform and the flow and concentration of the effluent will vary over a wide range. There are periods of great activity in the plant when the effluent may be very strong. Because of the wide variation in the effluent and since it is desirable to operate treatment facilities at a more uniform rate over as much of the entire day as possible, provision is made for storage and equalization. Air, if necessary, can be supplied to the effluents in the equalizing tank to avoid production of odour and septic conditions.

6.3 Biological Treatment — Dairy effluents contain all the nutrients for bacterial growth. Hence, they can be treated satisfactorily by using biological methods.

6.3.1 *Trickling Filters* — Results of dairy effluent treatment on trickling filters are good. Up to 95 percent reduction in BOD is possible with this process depending on recirculation ratio and the initial strength of the effluent. Two stage filtration was found to be more suitable. Factors to be considered in the application of trickling filters are:

a) adequate removal of suspended solids from the crude effluent by primary sedimentation,

b) *p*H of the influent to the filter should be within the optimum limits conducive for biological growth, and

c) BOD loading of 0·6 kg/m^3 of the filter medium for single stage filtration and 0·9 to 1·2 kg/m^3 for two-stage filtration may be adopted.

Modifications of conventional biological filtration developed so far for dairy effluents are:

a) alternating double filtration,

b) two stage filtration using plastics filter media,

c) fill-and-draw recirculating filter (for very small plants),

d) single stage recirculating filter, and

e) introduction of forced ventilation and recirculation with a high recirculation ratio.

Two stage biological filtration is known to remove 80 to 90 percent of BOD.

6.3.2 *Activated Sludge* — Activated sludge and its modifications like contact stabilization, extended aeration, etc, are found to be highly efficient in treating dairy effluents. The process has certain advantages over filtration such as lower construction costs, less area required for the plant and much lower effluent BOD values. However, power costs are higher and the process is sensitive to shock loadings. A loading of 0·3 to 0·5 kg BOD/kg MLSS/day may be adopted. The process will be expensive for treatment particularly from smaller dairies. The process is known to remove 85 to 95 percent of the BOD. Prerequisites for this method of treatment are:

a) pretreatment of the influent in the form of sedimentation before it is introduced into the aeration tank,

b) acclimatization of the seed sludge with the dairy effluent, and

c) need for digesting the excess activated sludge and sludge of the primary sedimentation tank.

6.3.3 *Oxidation Ditch* — Oxidation ditch has been found to be highly suitable under Indian conditions for the treatment of dairy effluents BOD reduction of 95 to 98 percent can be obtained. This system is much less expensive than conventional activated sludge in capital cost. Running costs are higher in this process. An organic loading of 0·12 to 0·15 kg BOD/kg MLSS/day may be adopted. Consistently good results have been obtained with oxidation ditches in Indian dairies.

6.3.4 *Aerated Lagoons* — Aerated lagoons can give BOD reduction from 50 to 90 percent depending on the aeration time, and are simple to operate. These have been successfully used in other countries for the treatment of dairy effluents. In India laboratory studies carried out have given encouraging results. Systems rate constant was found to be around 0·27 and detention time required for 90 percent BOD removal is about 4 days. This system is in between oxidation ditch and oxidation pond both in capital and running costs. The effluent contains considerable amount of suspended solids unless passed through a settling tank. Alternatively the aerated lagoon may be provided with settling chamber at the outlet end.

6.3.5 *Anaerobic Lagoons* — It has been reported that anaerobic treatment of dairy effluent has two main difficulties. If not properly seeded and operated, the lagoons tend to become sour due to increased acidity hindering the digestion process, and causing odour nuisance due to hydrogen sulphide and butyric acid. In spite of these disadvantages, anaerobic lagoon is being increasingly used as it is the cheapest method available for dairy effluents. Investigations in India on this process revealed that when properly seeded, anaerobic lagoons do not create odour nuisance. BOD reductions of 75 to 95 percent were observed at 4 to 10 days detention periods. The organic load for the anaerobic lagoon will be 200 to 300 kg BOD/1 000 m^3/day. This should form the primary consideration for the design of the lagoon. The lagoons are inexpensive to construct and to operate. Anaerobic treatment is usually followed by aerobic treatment in order to obtain an effluent which can be discharged into streams.

6.3.6 *Stabilization Ponds* — Stabilization ponds have been found to be good for treating mixtures of dairy effluents and sewage. Oil and grease should be removed from the effluents before treatment in stabilization ponds. A treatment system consisting of anaerobic lagoon followed by stabilization pond would be most economical and would not involve any mechanical equipment. By using stabilization pond alone, a reduction of 75 to 85 percent in BOD could be achieved. The BOD load to the stabilization pond will be 150 to 250 kg BOD/hectare/day depending upon the latitude of the place. However, for obvious reasons, the loading of stabilization pond when used after anaerobic lagoon will be about 75 percent. This system is cheapest in capital and running costs but would require substantial land area. Land requirements can be reduced considerably if oxidation ponds are used after anaerobic lagoon treatment.

6.4 Treatment Methods Recommended in India — Reviewing the methods mentioned above, treatment of dairy effluents in India should consist of the following:

a) Preliminary treatment of effluents,

b) Primary treatment of effluents, and

c) Secondary treatment of effluent.

6.4.1 *Preliminary Treatment* — This involves removal of oil and grease and coarse solids. Grease traps and screens are efficient and economical and are invariably used as an essential part of treatment by the dairies. This step is essential for any rational method of treatment or disposal. Provision for equalization of flows, and aeration to avoid production of odours and septic conditions is necessary.

6.4.2 *Primary Treatment* — Primary treatment as generally described in the waste treatment practice, that is, settling and digesting the sludge is not very useful for dairy effluents. However, dilution with water and anaerobic lagooning or aerated lagooning for a short period can reduce the BOD and suspended solids enough to facilitate disposal into sewers or on land for irrigation.

6.4.2.1 Dilution water required will be approximately 1 : 1 as the combined effluent from a common dairy is likely to have below 1 200 mg/l suspended solids and about 1 000 mg/l BOD (*A* in Fig. 2). The BOD and suspended solids can also be reduced to 50 percent to suit the limits of the sewers and land irrigation by treating in anaerobic lagoons (6 days) (*B* in Fig. 2) or aerated lagoons (1·5 days) (*C* in Fig. 2). The dilution requirement and the detention periods required in the lagoons may have to be modified depending upon the effluent characteristics.

6.4.3 *Secondary Treatment* — Secondary treatment is required for further reduction of BOD to suit the inland surface water standard. The secondary treatment would consist of one of the following systems:

a) Oxidation ditch,

b) Aerated lagoon, and

c) Anaerobic lagoon followed by stabilization pond.

6.4.3.1 Oxidation ditch is preferred by several dairies because of its compact nature and simplicity in construction and operation. The oxidation ditch (*A* in Fig. 3) can be loaded at 0·2 kg BOD/kg MLSS/day. The BOD reduction that can be expected would be 95 to 98 percent.

6.4.3.2 The aerated lagoon (*B* in Fig. 3) is designed to have a detention time of 3·7 days to get a 90 percent BOD reduction.

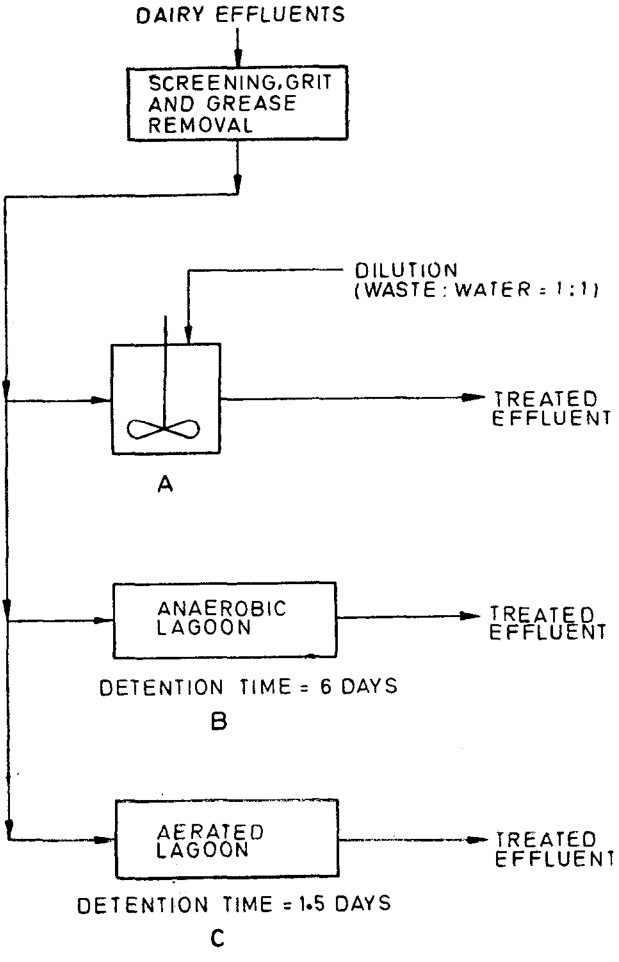

FIG. 2 ALTERNATIVE FLOWSHEETS FOR THE TREATMENT OF DAIRY EFFLUENTS FOR DISPOSAL INTO PUBLIC SEWERS OR ON LAND FOR IRRIGATION.

6.4.3.3 Anaerobic lagoon treatment for 10 days would help reduce the BOD by 90 percent. It is desirable to reduce the residual BOD by aerated lagoons or oxidation ponds or by dilution with water. One of the above methods would help to 'sweeten' the effluent, that is, to reduce the septicity or increase the oxidation reduction potential.

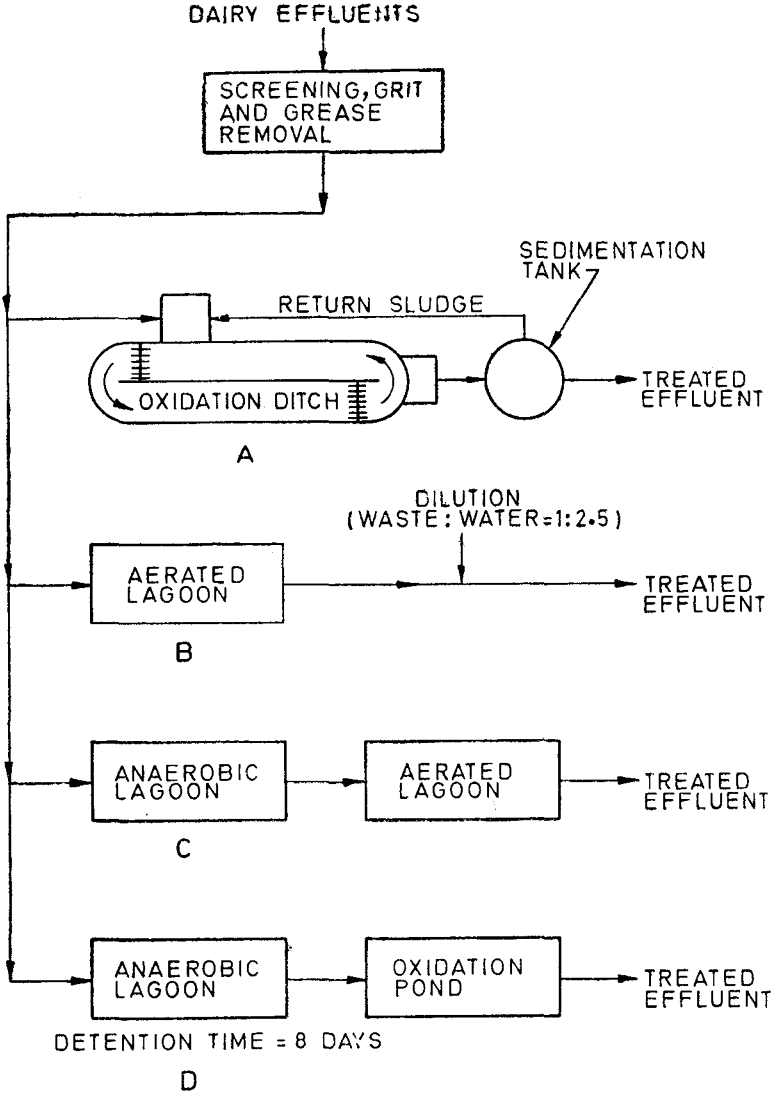

FIG. 3 ALTERNATIVE FLOWSHEETS FOR THE TREATMENT OF DAIRY EFFLUENTS TO BE DISCHARGED INTO INLAND SURFACE WATERS

APPENDIX A

(*Clause* 0.3)

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